CHAPTER 2
STEP-WISE GUIDANCE

2.1 IDENTIFY SPECIFIC PURPOSE OF STUDY

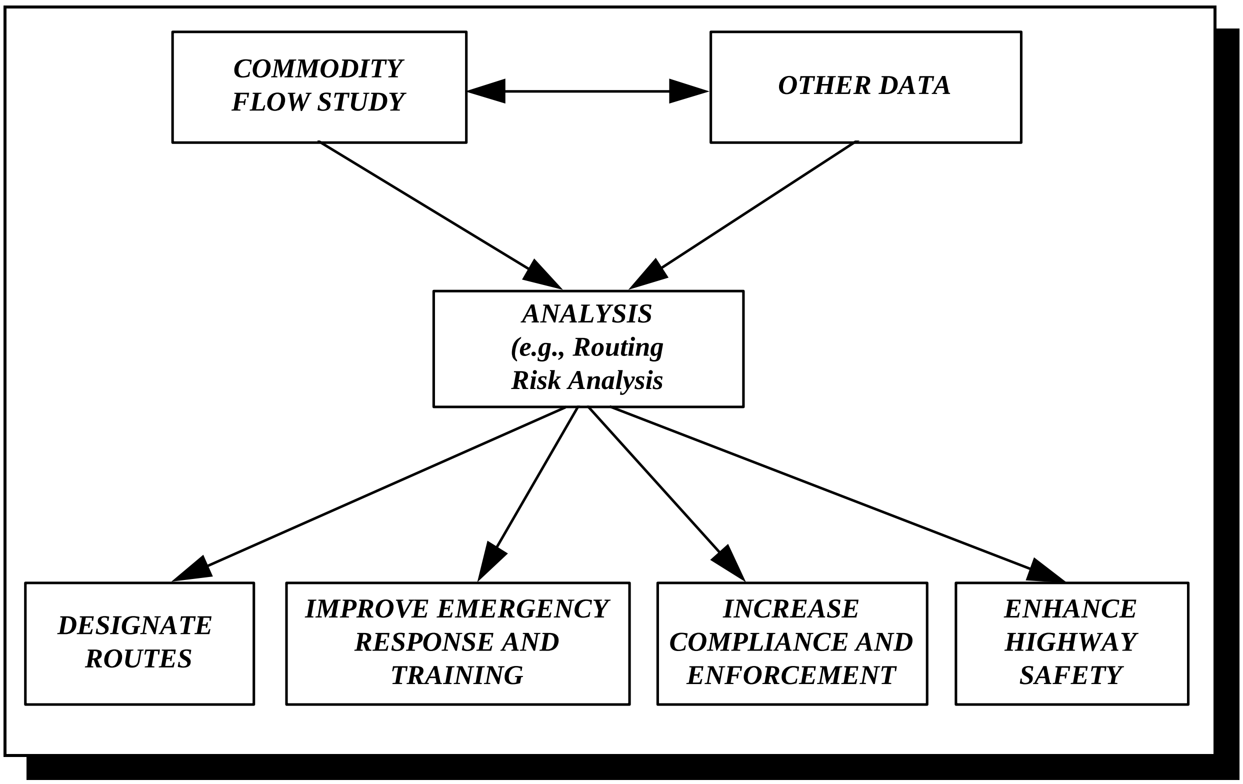
A commodity flow study is the collection of data on transportation patterns within a jurisdiction. There are a variety of activities and survey methods that can be used to perform a commodity flow survey; many include a road-side survey where truck data (e.g., placard type, UN/NA commodity number, route used, truck type) are recorded and some form of driver interview is conducted. Depending on the methods used and goals of the study, some subset of the information listed below can be gathered for a particular hazardous materials commodity flow study:

- Major traffic corridors used.
- Primary origin and destination locations.
- Primary hazard classes transported.
- Actual materials transported.
- Hazardous materials tonnages shipped.
- Number of hazardous materials trucks.
- Fraction of hazardous materials traffic in all truck traffic.
- Truck types used for hazardous materials.
- Container types used for hazardous materials.
- Driver training and awareness.
- Degree of regulatory compliance.
- Peak transportation times and days.
- Seasonal transportation variations.

A jurisdiction will have specific objectives for conducting a commodity flow study based on its particular needs; frequently, a commodity flow study is only one element of a larger study, such as a hazardous materials routing analysis. Most larger studies will require the use of numerous data sources, with the commodity flow study providing a characterization of the traffic and hazardous materials flows within a jurisdiction. There are many other sources of data that can be used in conjunction with the data from a commodity flow study, including databases that provide information on a local, statewide, regional, or national basis, as well as industry associations and state and local planning organizations; potentially available data may include population data, annual accident type and location data, and annual average shipments by hazard class/division.

Exhibit 2 illustrates the interplay of data for a larger study. Both data from a commodity flow study and other sources may be required; in addition, either data set can be used to enhance the other. For example, statewide accident data can be used to identify routes to be surveyed in a commodity flow study. Likewise, an estimate of the average hazardous materials transportation from a commodity flow study can be compared to statewide accident data to determine accident frequencies. Both data sets contribute to the analysis for the main objective. For a routing designation, this objective would be a routing risk analysis; for enhancing highway safety, this could include a comparison of the routes frequently used with data on the physical condition of those routes. The results are then used to implement the objective of the main study, and may result in some variety of emergency response improvement, regulatory compliance increases, route designation, or highway safety enhancements.

EXHIBIT 2
THE USE OF DATA FROM A COMMODITY FLOW SURVEY



In general, hazardous materials commodity flow studies are used for two main highway transportation activities: the designation of transportation routes and the formulation of planning programs.

Within the scope of analyzing transportation patterns, commodity flow studies can be used for routing risk analyses that formulate the basis for route designation. Several applications of commodity flow study data are identified below:

- Origin and destination data collected from a commodity flow study can be used to determine the relative amounts of through traffic (origin and destination out of state) and intrastate traffic (origin, destination, or both in the state). These data could also assist in identifying the locations in need of designated routes.

- Prior to route designation, a state must consider, analyze, and compare feasible alternatives. A commodity flow survey could assist by identifying the current route(s) used.

< Data from a commodity flow study on the types and quantities of materials carried could be used in the consequence assessment component of a routing risk analysis.

Within the scope of planning, a commodity flow study can contribute to an analysis of current programs and help in assessing future needs. Specific examples are identified below:

< Used with data on equipment distribution, training and preparedness of response personnel, and accident rates, data on driver training and compliance from a commodity flow study could assist in identification of training needs and staffing requirements for emergency responders and strategic deployment of hazardous materials response teams.

< A commodity flow study could provide data on the hazard classes and individual hazardous materials being transported through the state; these data could pinpoint specific, extremely high-risk chemicals that require specific training or preparedness efforts.

< Many commodity flow studies include a review of shipping papers to identify shipment content and destination. This information, compared to Federal, state, and local regulations, could assist in determining rates of shipper compliance with hazardous materials transportation regulations.

< Data from a commodity flow study on frequency of route usage could be used with accident and roadway conditions data to assist in allocating resources for such measures as highway improvements that enhance public safety.

< The commodity flow data could be compiled to provide an average daily or annual profile of commercially transported hazardous materials in the jurisdiction. These data could provide the jurisdiction with baseline data that, compared with data from multiple sampling events, could highlight changing transportation patterns and needs.

These goals do not cover the entire range of objectives for which hazardous materials commodity flow studies can be used. However, these examples can be used as a starting point to illustrate the variety of ways in which data from a commodity flow study can be used to fulfill the data requirements for larger analyses.

2.2 REVIEW BASELINE INFORMATION

To select routes to focus on during the study, it is important to determine which roads within a geographic area are capable of supporting hazardous materials and to identify the amounts and types of materials that are being transported over those roads. The information sources discussed in this section support this determination.

2.2.1 Identify Roads Available for Hazardous Materials Transportation

By determining which roads are physically accessible for hazardous materials transportation, the scope of the commodity flow study can be narrowed. Identification of the routes that are capable of carrying hazardous materials can be completed fairly quickly by examining state and county maps, road atlases produced for the trucking industry, and familiarity with the study area. Rand McNally publishes an atlas that shows the legal weight truck route system in each state; communities located on one of these routes can be fairly certain that hazardous materials, particularly gasoline, are passing through at some point during the year. Updated annually, the *Motor Carrier's Road Atlas* is available at retail outlets or by calling Rand McNally at (800) 284-6565.

2.2.1.1 Local Statutes

Some communities have passed legislation restricting the movement of hazardous materials on certain routes. It is advisable to check with local officials to learn about any ordinances that may regulate hazardous materials, particularly for any routes which have bridges or tunnels, which may have restrictions regarding hazardous materials traffic.

2.2.1.2 Highway Performance Monitoring System (HPMS)

The Highway Performance Monitoring System (HPMS) is a joint effort of Federal, state, and local governments. Data are reported by state highway agencies, in cooperation with local governmental units, metropolitan planning organizations, and other organizations. HPMS includes data on lane widths, road capacity, curves and grades, as well as information for all public road and street facilities within each state, including system type (e.g., Federal or state highway) and functional type (e.g., arterial, collector, toll).

> Information regarding the acquisition of data items in the HPMS can be obtained from:
>
> U.S. Department of Transportation
> Federal Highway Administration
> Office of Highway Information Management
> 400 Seventh St., S.W.
> Washington, DC 20590
> (202) 366-0180

These data are used by the Federal Highway Administration to estimate truck volume, as a percentage of traffic, on each link (or segment) in the system. Although truck volumes are not categorized by commodity, a commodity profile (i.e., relative frequency of movement by commodity code) for the area of interest could be matched to these data to estimate roughly annual shipment tonnages by commodity by link.

2.2.2 Highway-Specific Information

After identifying the roads available for hazardous materials transportation, the next step is to assemble data pertaining to those routes. Data on the types of vehicles using those routes, accident histories, and information on the specific commodities transported may be available from public and private organizations at the national, state, and local level. Collecting this information before beginning a field investigation conserves valuable resources by not duplicating data collection efforts. Several of these sources are described below and are summarized in Exhibit 3. Contact the state department of transportation and turnpike authority for more information on data they may have collected.

2.2.2.1 Truck Flow

An essential element to a commodity flow study is the average expected truck volumes for the study area. The following national sources of information can provide data on truck volumes by state (often estimated from national averages), providing indicators of how many trucks and what types of truck (e.g., tank truck, trailer-tractor) are typically traveling through the area.

Commodity Transportation Survey (CTS). The Commodity Transportation Survey (CTS), which is maintained by the U.S. Bureau of the Census, provides the means to estimate market shares and shipment trends of goods manufactured in the United States. The CTS covers all transportation modes, and therefore is not specific to highway shipments. It contains data on shipments only from the point of manufacture to the first destination and does not specifically focus on hazardous materials. Data sources include bills of lading, sales invoices, and other shipping documents for a stratified sample of 19,500 manufacturing establishments drawn from the 1977 Census of Manufacturers.

The Bureau of the Census conducted a Commodity Flow Survey during 1993. This survey features expanded industry coverage relative to its 1977 predecessor. For the first time, flows of hazardous materials (identified by 5-digit Standard Transportation Commodity Classification code) will be flagged and separately tabulated. Survey results are expected to be available in 1995. The data (tons, ton-miles, and value of commodities shipped by manufacturers) are classified by commodity type, means of transport, length of haul, weight, and shipment destinations.

EXHIBIT 3
SOURCES OF EXISTING DATA

Databases and Other Statistical Reports

Commodity Transportation Survey ! Total U.S. flow of each hazardous material by volume shipped

HPMS/FHWA ! Approximate state total truck miles

Truck Inventory and Use Survey ! Hazardous materials carried by trucks registered in state

HMIS ! Hazardous material transportation accident type and location data

Safety Net (OMC 50-T) - Accident information including carrier identification, location, and cargo description

LEPCs and Other Planning Groups

Data provided through TRANSCAER

Substances that originate and terminate locally

Quantities stored locally

Existing Studies

Findings of studies in neighboring or other states

SRI Study (See Appendix A)

Truck Inventory and Use Survey (TIUS). The Truck Inventory and Use Survey (TIUS) is maintained by the U.S. Bureau of the Census, and is part of the Census of Transportation which is conducted once every 5 years. Reports for 1977, 1982 and 1987 are currently available; the 1992 report is expected to be published early in 1995. The TIUS provides data on the physical and operational characteristics of the nation's trucks. Also, hazardous materials truck miles by state are provided. Truck type and truck-mile data for hazardous shipments are included, but origin and destination data are not.

Forms for ordering CTS and TIUS reports can be obtained from Department of Commerce district offices or from:

Customer Services Branch
Data User Services Division
U.S. Bureau of the Census
Washington, DC 20233
(301) 763-7662

The TIUS contains such information as:

- Physical characteristics of each vehicle.
- Operator class.

<	Annual mileage and range of operation.

<	Percentage of miles operated in home state.

<	Commodities carried by hazard class.

<	Percentage of travel miles accounted for by hazardous materials shipments.

Published data from the above two surveys are also available on computer tapes that contain discrete rather than summary data. Depending upon the goals of a study and the quality of data available, the discrete data may be more useful and reduce unnecessary repetitive research.

2.2.2.2 Accident History

Another important data set is the determination of the number, location, and types of accidents occurring in the survey area. The historical record of local transportation accidents and incidents is useful because many carriers are consistent in their routing practices. In other words, if an accident involving a specific substance, occurred during shipment from an origin to a destination, the same route is probably still being used for shipments of that substance, and probably for shipments to other points as well. Even in the absence of detailed records, valuable information can be obtained from newspaper files, from state and local police reports, and from interviews with local emergency responders. The following sources can provide information on highway releases of hazardous materials as well as average accident rates.

Hazardous Materials Incident Reporting System (HMIS). The Hazardous Materials Incident Reporting System (HMIS) became the official Federal record keeping system for hazardous materials release data since 1971, and is maintained by the U.S. Department of Transportation. A release is defined as an unintentional release of a hazardous material during or in connection with its transport. All rail, truck, non-bulk water and air releases occurring during interstate commerce are covered by the HMIS. However, intrastate highway and bulk marine transport are excluded. 49 CFR Sec. 171.16 requires detailed, written hazardous materials incident reports to be submitted, within 30 days of the date of the incident, to the Department of Transportation for each incident that occurs during the course of transportation (including loading, unloading, and temporary storage). HMIS allows isolation of incidents involving specific hazardous materials. Approximately 182,000 records were in the file as of December, 1990. Required reporting categories are listed in Exhibit 4.

> HMIS data for a single year can be obtained on diskette; additional data may require the use of open reel tape. For more information, contact:
>
> U.S. Department of Transportation
> Research and Special Programs Administration
> Information Systems Unit, DHM-63, Room 8112
> 400 Seventh Street, S.W.
> Washington, D.C. 20590
> (202) 366-4555

The HAZMAT (incident record) file includes information about the incident and hazardous material(s) involved. A second file, the HAZCON file, reports details about the hazardous material container(s) involved in each accident (e.g., container type, container capacity, number of failed containers, label or placard, cause of failure).

EXHIBIT 4
INCIDENTS REPORTED IN HMIS

As the direct result of the presence of hazardous materials:

< A person is killed or receives injuries requiring hospitalization.

< Estimated carrier or other property damage exceeds $50,000.

< An evacuation of the general public occurs lasting one hour or more.

< One or more major transportation arteries or facilities are closed or shut down for one hour or more.

< The operational flight pattern or routine of an aircraft is altered.

< Fire, breakage, spillage, or suspected radioactive contamination occurs involving shipment of radioactive material or etiologic agents.

< A situation exists of such a nature that, in the judgment of the carrier, it should be reported to the Department even though it does not meet specific criteria of these categories.

< There has been an unintentional release of hazardous materials from a package (including a tank).

< Any quantity of hazardous waste has been discharged during transportation.

Office of Motor Carriers. Since 1973, the U.S. Department of Transportation, Federal Highway Administration, Office of Motor Carriers (OMC) (formerly the Bureau of Motor Carrier Safety) has maintained a database of accidents involving motor carriers of property.

From 1973 to 1993, accidents were reported to the OMC and reports were filed on Form 50-T. A "reportable accident" was an occurrence involving a motor vehicle engaged in the interstate, foreign, or intrastate operations of a motor carrier that resulted in:

< The death of a human being.

< Bodily injury to a person who, as a result of the injury, immediately receives medical treatment away from the scene of the accident.

< Total damage to all property that aggregates to $4,400 or more based upon actual costs or reliable estimates.

The 50-T file is available on open reel tape. The Safety Net file is available upon written request. Details may be obtained from:

U.S. Department of Transportation
Federal Highway Administration
Office of Motor Carriers
400 Seventh Street, S.W.
Washington, D.C. 20590
Contact: Linda Giles
(202) 366-2971

In addition, commercial sources have prepared reports (on a state or national basis) that present and analyze OMC 50-T data.

From 1973 to 1985 the minimum property damage threshold for reporting was $2,000. The minimum damage threshold was raised to $4,200 in January 1986 and to $4,400 in March 1987.

Form 50-T requested carrier identification and address, location of the incident, characteristics of the event, cause, information on the cargo, and consequences of the accident. The carrier identification, cargo description, and certain accident characteristics were recorded, so that users of the HMIS database and the OMC 50-T database might compare data on releases caused by vehicular accidents. In a small percentage of the records, the milepoint data was also included, resulting in more precise accident location determination. The 50-T accident file, which is no longer updated but still available, contains a hazardous materials flag that permits the isolation of vehicular accidents involving hazardous materials.

As of 1993, the OMC no longer collects the Form 50-T. The new **Safety Net** database supersedes the OMC 50-T database. Accident information from March of 1993 on is now collected by the OMC from police accident reports and put into the Safety Net database. The reports include commercial vehicles of 26,000 lbs. or more, that are involved in an accident resulting in a fatality, injury, or tow away. The OMC is collecting these reports from 40 states for the Safety Net database at this time, and the remaining states should be included sometime during 1995.

2.2.2.3 Commodity Type

The above data sources on road type, truck volumes, and accident rates should provide a general overview of the average truck flow within the study area. Information on hazardous materials volumes, usually by hazard class, may also be collected (Exhibit 1 describes the DOT hazard classification system). Planners should keep in mind that these data are general and often based on national averages; this information, however, can help to focus further research on specific truck types or hazard classes passing through the study area. Data sources discussed in this section are for collecting information on hazard classes and specific commodities.

Determining specific or even general types of hazardous materials that are transported through the study area can be one objective of a commodity flow study. Keep in mind, however, that it may be very difficult to identify every single chemical that passes through a jurisdiction. Depending on the nature and amount of hazardous materials traffic, it might be advisable to concentrate on determining which general classes of chemicals (e.g., flammables, corrosives) are being transported. Planners involved in a commodity flow study in the Kanawha Valley region of West Virginia (an area with an extremely high concentration of chemical manufacturers and shippers) learned that there were just too many individual chemicals being transported through the region to study each in depth or to focus planning efforts on each individually. They concentrated on determining general classes of chemicals instead. The following sections discuss several sources of existing information on commodity type.

Information Developed under SARA Title III. The reporting requirements of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) have increased the information that is available about hazardous materials stored in fixed facilities; unfortunately, information on the transport of hazardous materials is neither required nor typically provided to Local Emergency Planning Committees (LEPCs). However, important information can be surmised from the materials submitted to LEPCs.

Information about substances used to produce the final products at a manufacturing plant can be a key indicator of local hazardous materials flow patterns. For example, a chemical plant producing nylon is likely to receive shipments of and/or store significant quantities of furan or furfural. These materials, classified as flammable liquids, are used extensively in processing nylon and are frequently transported by road and rail. Thus, even though data provided by the plant to the LEPC may not explicitly state that such process chemicals are being received from shippers, if they are not produced on site, it may be assumed that they are transported to the plant.

Because each facility must submit information regarding the specific amounts of hazardous materials located on site, both the type and quantity of substances likely to be involved in locally originating and terminating shipments are a matter of public record. LEPC(s) within the study area can provide a list of facilities that report under SARA Title III, including specific substances used on site.

National Associations/Other Sources. Industry associations and other private organizations can be an important resource for collecting existing information. Associations such as the American

Trucking Association, National Association of Chemical Distributors, National Tank Truck Carriers, the American Petroleum Institute, the Chemical Manufacturers Association, and the International Bridge Turnpike and Tunnel Association (IBTTA) may be able to provide data, resources, and/or contacts in a jurisdiction to aid in commodity flow study efforts. Addresses and phone numbers for each of these associations is provided in Exhibit 5.

EXHIBIT 5
ADDRESSES FOR SELECTED NATIONAL ASSOCIATIONS

American Trucking Associations
2200 Mill Road
Alexandria, VA 22314
703-838-1700

National Association of Chemical Distributors
1101 17th Street, N.W.
Suite 1200
Washington, D.C. 20036
202-296-9200

National Tank Truck Carriers Inc.
2200 Mill Road
Alexandria, VA 22314
703-838-1960

American Petroleum Institute
1220 L Street, N.W.
Washington, D.C. 20005
202-682-8000

Chemical Manufacturers Association
2501 M Street, N.W.
Washington, D.C. 20037
202-887-1100

International Bridge Tunnel and Turnpike Association
2120 L Street, N.W.
Suite 305
Washington, D.C. 20037
202-659-4620

State agencies can provide information on industries, transportation routes, accident histories, and other data within a specific geographic area. The state transportation department may be able to provide information on transporters registered in-state, depending on state law. The state department of environmental protection or natural resources as well as state and local health departments may be able to provide information on known health risks and accident rates, as well as sensitive populations that may require protection (e.g., homes for the elderly, schools) during an incident. State economic development agencies or the state department of environmental protection may have data on facilities registered in-state, including information on materials manufactured or stored on-site. Through the state turnpike authority, the IBTTA can assist collecting original data.

Transportation Community Awareness and Emergency Response (TRANSCAER) is a nationwide community outreach program developed by the Chemical Manufacturers Association (CMA) and implemented by CMA-member firms that ship hazardous materials. Its purpose, in part, is to encourage partnerships between citizens and industry to develop mutual understanding about the transport of hazardous materials and to help community emergency planning groups identify hazardous materials moving through their communities. Industry representatives work with the LEPC and/or local responders and planners to improve awareness and response capabilities by providing information and resources. Additional information can be obtained from CMA (see Exhibit 5).

2.3 DESIGN THE STUDY

By comparing the data collected from the sources discussed above with the project goals, it should be possible to determine whether a field investigation should be undertaken. Because the existing data may prove to be out of date or the study's goals might require more specific data than is already available, it may be necessary to collect original data. For example, if the goal of the study is to quantify the level of awareness of drivers carrying specific high-risk chemicals, additional analysis and/or field surveys that supplement existing data will probably be necessary.

2.3.1 Survey Locations

> IDAHO - Peak Transportation Times. Idaho's risk assessment was conducted by surveying truck traffic at eight sites. To obtain data representative of weekly information, each location was surveyed for three days, once in July, and once in August. A total of 46 survey events, all over three days of the week (Sunday - Tuesday) occurred. Although the survey did not cover the entire week, the data gathered did allow initial conclusions to be made about which days and hours in the first part of the week are peak transportation times. These data can be useful for emergency response planning and scheduling.

If a hazardous materials flow study can be made part of a routine function, such as port-of-entry and weigh-station checks, collecting original data can be minimally disruptive and less likely to burden the carrier. However, such data will largely reflect interstate movements and may therefore miss sizable intrastate shipments.

Many states conduct random safety checks of heavy trucks in transit through their jurisdictions, occasionally utilizing rest stops that afford a safe location for extensive vehicular examination. Shipping paper information can be recorded during the safety examination. Because rest stops are distributed throughout a state's highway network (though chiefly on the Interstate system), they are better than points of entry or established weigh stations for surveying of intrastate movements. In general, survey teams should set up wherever there are appropriate combinations of the following:

< High truck volumes.

< Adequate space for safe pullover and isolation of up to about five trucks from the flow of traffic.

< Good visibility along the highway, in the event it becomes necessary to allow trucks to pass by because of long queues without recording shipping data. In this case, placards could still be read and noted.

< Absence of legal restrictions on survey activity.

< At least one other valid reason (e.g., cargo check, safety check, or weight check) for pulling the vehicle off the highway.

The study should keep in mind that truckers may evade the survey point either to save time or to conceal something. Alternate routes in a corridor are generally few in number and easy to identify. As a contingency, an individual should be stationed on each of these alternate routes to record the placards of drive-by trucks.

One type of easily accessible location for surveying trucks is points of entry, that is, state line crossings. States commonly locate a rest area just before or after state line crossings. Establishing a survey location at one or more of these rest areas (points of entry) would include trucks just as they were entering or exiting the state, and could provide information on the percentages of trucks that are passing through, importing to, or exporting materials from the state. These locations would not, however, survey all truck shipments that both originate and terminate within the state.

Depending on the purpose of the study, it may be useful to divide the routes being studied into segments or "links" to track commodity movements between specific points. Typically, this type of survey would require a large commitment of resources and would be conducted for a survey of an entire state because it requires a large number of survey locations and/or extensive interviews with drivers. Using links is useful because it provides more information on travel between two sites on the same (or adjoining) roads, rather than general information on truck volume on a particular route. For example, by using links, it would be possible to determine that truck volume is higher on a segment of an east-west highway between interchanges with two major north-south highways. It may be useful to consider Points A and B as the end points of the east-west highway interchanges X and Y with 2 north-south highways in between them. If the east-west highway is surveyed only at endpoints A and B, the traffic using the highway only for the connecting link between interchanges X and Y and the north-south highways would be missed. Under these circumstances, it would be important to collect data between interchanges X and Y.

NEVADA ! Links. By locating survey sites throughout the state and dividing the roads into links, Nevada was able to create an overview of statewide hazardous materials transportation. To obtain an average daily profile of commercially transported commodities via Nevada's highway system a total of 45 statewide information collection sites were used, including 19 points of entry, scattered across the state. The routes were divided into 95 "links" to track commodity movement.

At the conclusion of the study, each of the 95 links was analyzed to determine the average daily volume of hazardous materials, and the links were mapped accordingly. Using links identifies frequencies along specific route segments, instead of frequencies along an entire route, which can misrepresent traffic volumes. The mapping method employed is also useful because it creates a reference to identify at a glance the routes used most frequently, as well as the connector roads or segments of roads used as feeders to the major highway system, without having to know and compare exact volumes shipped over different routes.

The routing plans of highway common carriers tend to favor the interstate system because this network offers the most direct, fastest, and safest alternative. Nevertheless, legal-weight carriers are restricted to routes designated by the requirements of the Surface Transportation Assistance Act (STAA) of 1982 which are numerous in some states. Carriers may avoid an Interstate option if the delay, including weight, cargo, safety, and shipping paper checks, is less on another route with a lower classification.

2.3.2 Seasonal/Repetition

To obtain the most representative data, it is advisable to conduct field studies using numerous repetitions during multiple seasons. Using a continuous survey of truck traffic on consecutive days during at least two distinct seasons of the year may well represent a minimally acceptable standard for overcoming the sampling difficulties as discussed in section 2.5 below. Surveying for an entire week during

OREGON ! Multiple survey events and seasons. Oregon spread its survey over eight months to identify seasonal variations in transportation. The entire survey was completed in three phases, over a total of 18 days consisting of periods that began on a Monday or Tuesday at 12:01 am and continued for 72 hours (3 days). Phases one and two were conducted in March and August at seven sites outbound from Portland. In phase three, hazardous materials shipments entering Oregon through four border ports of entry were surveyed during the third week of November.

The use of three survey periods assists in identifying seasonal differences in truck traffic and hazardous materials shipments. Ideally, a survey to identify seasonal variations would be done at the same sites for each of the multiple events. Despite the fact that Oregon's third phase was conducted at different sites, the data from the seven sites surveyed twice can be used to make initial conclusions about seasonal traffic variations.

more than one season may be somewhat better, though undoubtedly more resource intensive. The selection of survey weeks should take into account the relevant economic characteristics of the area being studied (e.g., agricultural cycles, heating oil stockpiling, and industrial production schedules). To contain costs and collect data that are statistically reliable, it may be preferable to conduct field studies for two full weeks in a given month (not necessarily consecutive weeks) with identical follow-up surveys within four to six months after the initial surveys.

2.3.3 Personnel Needs

Law enforcement personnel, technical staff of state administrative departments, and college students have all been employed to collect hazardous materials flow data. No particular technical qualifications are required to perform field duties beyond the ability to read and record verbal or printed information accurately. However, technical qualifications would be required for interpreting and analyzing the data. All survey staff should attend at least one training session in survey procedures to facilitate data collection. This session should precede actual data collection by no more than one week and should include opportunities for personnel to demonstrate their competence. Survey staff can also participate in dry runs at the survey site that involve transport trucks and interactions with persons playing the role of driver. It is also very important that an individual understand and appreciate the survey's purpose. The goals of and rationale for conducting the survey should be central themes of the training sessions.

Staffing needs (in person-hours) will vary with the scope of the survey, irrespective of staff qualifications. If a survey is expected to reflect daily and seasonal fluctuations in hazardous materials flows at locations across a state, the person-hours required for data collection and transcription will be much larger than if a survey is intended only to reflect an average one day truck flow. If there are multiple sampling points in a state with a dense network of designated legal truck routes or a large number of origins and destinations of hazardous materials, the required person-hours will probably be much larger. Personnel considerations for surveys that have been conducted (and are discussed in more detail in Chapter 3) include the following:

< Idaho's study was conducted predominantly in daylight hours and spanned seven calendar months, three of which were survey months. The 1,520 person-hours involved in this study indicate that survey staff worked an eight-hour day at each of two locations.

< By contrast, Oregon's 3,460 person-hour effort involved continuous 72-hour monitoring periods at 11 sites; thus, each of the study's three phases required at least 99 eight-hour (two-person) shifts. The effort expended by the truck inspectors added to the total.

< In the case of the Dallas/Ft. Worth survey, the 100 person-hour commitment was probably appropriate for the spot survey procedure adopted, that is, no truck pullovers, no interviews, and no examination of shipping papers. However, the vigilance required to spot, record, and count all passing placarded trucks dictated shifts no longer than four hours. Accuracy is important, especially in the transcription of placard codes and verbal lading descriptions.

2.3.4 Study Design and Resources

Prior to conducting the commodity flow survey, it will be necessary to ensure that the goals of the survey can be achieved by the study method, and that the method requirements can be met by the resources allocated to the survey. It is important to take some time to review the study and determine whether any modifications are required and determine whether the study needs can be met by the resources available. Budget resources, personnel, equipment, and time restrictions imposed upon the survey must all be considered. If the needs cannot be met by the resources allocated, it may be necessary to restrict some portions of the survey. For example, a survey may require three surveys to be conducted over a period of one year, using three people at each of 25 locations for each survey. If seasonal variations are more important than obtaining detailed statewide information, it might be appropriate to reduce the number of survey locations while keeping the three survey seasons. Likewise, if statewide variations are vital, having only two surveys at each of the 25 sites may be more practical. Reviewing the survey objectives and study design side by side is an important step in ensuring that the survey results are achieved within the resources allocated for that purpose and that they are meaningful in achieving the stated goal of the survey.

2.4 COLLECT ORIGINAL DATA - FIELD SURVEYS

Field surveys provide the additional data necessary for a more thorough analysis of transportation-related hazardous materials risks. There are several different methods that can be used for collecting data in the field, each requiring a varying degree of effort. This section discusses various methods for collecting original data in the field as well as issues regarding data recording and data storage. Exhibit 6 reviews the specific information to be collected. The applicability of each method (listed in increasing order of the resources required to complete the effort) to the study's design and overall goals should be considered. These various methods may be used in combination, as appropriate, to maximize the amount of data collected.

EXHIBIT 6
INFORMATION TO BE RECORDED DURING FIELD SURVEYS

SOURCE	MINIMAL DATA	ADDITIONAL DATA
SURVEY PERSONNEL	T Date and time sample record was taken	
VEHICLE	T Truck type T Cargo type T DOT placard T Four digit UN/NA ID #	Ú Tank or trailer rated capacity
SHIPPING PAPERS	T Any routing instructions T Four digit UN/NA commodity T ID # (Compare with placard) T Destination of shipment (city and state)	Ú Four digit STCC code number Ú DOT shipping name Ú Quantity of lading (weight or volume) Ú Origin of shipment (city and state)

2.4.1 <u>Data Collection Methods</u>

The following data collection methods will provide, at a minimum, the placard color and type and the four-digit ID code. These data should be recorded and then checked for consistency with shipping paper information. Recording the rated capacity of each tank or trailer provides an indication of the total quantities of specific substances (or hazard classes) being transported and the potential magnitudes of spills or releases in the event of an accident.

2.4.1.1 Placard Surveys

It is relatively easy to determine the hazard class of the contents of a properly placarded truck trailer (see Exhibit 7 for examples of placards and identification numbers). Survey personnel note the material's identification number displayed on trucks moving past a survey point. Binoculars, of course, can assist in reading the four digit ID number, which is displayed either on the placard itself, on an orange panel below the placard, or on the side of the vehicle.

Sheriff's deputies or local law enforcement personnel on routine patrol may be able to conduct these informal checks if they are stationed at or near road arteries passing through the community. Properly trained volunteers (e.g., students, environmental groups) can also provide valuable resources. It is important to select a location for personnel that is safe and has a clear line-of-sight to the right-of-way.

2.4.1.2 Review of Shipping Papers

Each vehicle's shipping papers contains precise information on the quantities and types of hazardous materials being transported. The shipping papers for vehicles transporting hazardous materials must contain:

- Number of packages of lading.
- DOT shipping name of lading.
- DOT hazard class of lading.
- UN/NA four-digit ID number.
- Package weight or volume for each product carried.

In addition, virtually all bills of lading identify either the shipper or forwarding carrier from which the consignment was received, the point of origin of the shipment (or location of receipt), and the shipment's point of destination. There may also be special handling instructions for the driver and recipient, as well as a routing plan for the driver. This plan may be spelled out in some detail, but in general provides only the sequence of routes to be followed (e.g., US 45 north to I-65 north to I-90 east). Comparing the routing instructions with the points of origin and destination can provide a quick quality assurance check.

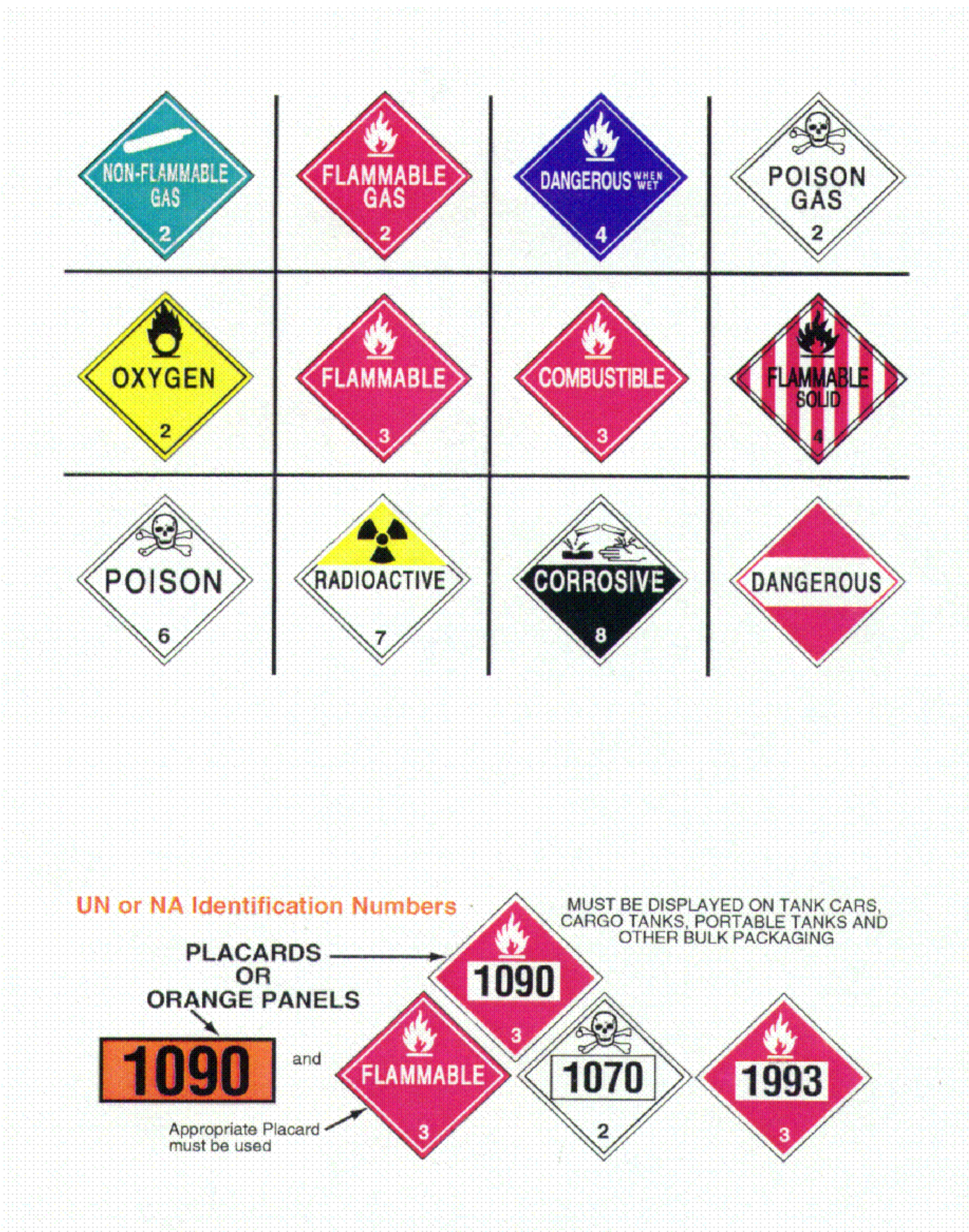
As trucks pull into the survey area, survey personnel should ask the driver for the shipping papers, which should be readily available. For any hazardous materials shipment, a copy of the shipping papers and any other relevant documents must be placed in the cab before starting the haul.

Survey personnel could be tasked to photocopy the shipping papers while the truck is stopped at a toll booth or weigh station and additional information from the vehicle is recorded. Minimizing the delay to the driver, this approach allows for a detailed examination of the information on the shipping papers away from the site after the field surveys are complete. It is important to note that shipping papers are not standardized; the review process, therefore, could prove lengthy. In addition, the cost of maintaining portable copiers at the survey locations may be prohibitive to some jurisdictions.

2.4.1.3 Driver Interviews

Driver interviews provide "hands on" information. A list of questions should be prepared and survey personnel should be briefed on the types of information to look for. The survey goals will point to the correct questions to ask, for example: If the driver works for a particular company often, does

EXHIBIT 7
EXAMPLES OF PLACARDS AND IDENTIFICATION NUMBERS



he/she typically use the same route? Does he/she usually have the same destination? If so, what is that destination? Is it in-state? Out of state? Is the driver familiar with the material being transported? What type of safety training has he/she received?

2.4.1.4 Facility Survey

If resources allow, distribute a questionnaire to facilities within the study area to obtain precise shipping data. These facilities can be polled to determine specific trends in the amount of hazardous materials transported, the exact mode and route of transport, and the usual hours and days of the week for shipping and receiving. Time must be allowed for conducting follow-up telephone calls to clarify information that may be unclear. Telephone calls can also help increase the rate of response.

> DALLAS CBD ! Facility Survey. The Dallas CBD inventoried local industries to identify the types of hazardous materials transported locally, the routes used, and the frequency and time of day for the shipments. An industry survey was sent to 1,400 Dallas and Dallas County industries and transporters that were selected based on SIC code and identified from several information sources, including Federal, state, local, and private agencies.
>
> From the inventories, it was possible to determine that the majority of bulk shipments were gasoline or petroleum-related, and a number of other materials were regularly being shipped through the area. The data indicated that as many as 25-30 9,000-gallon shipments of gasoline traveled in proximity to the Dallas CBD each day. By obtaining these data prior to conducting a field survey, it is possible to save effort and resources by narrowing the focus of the field study to specific areas and commodities.

2.4.2 Recording Procedures

All data gathered should be accompanied by the date and time they were recorded and should reflect visual inspection of the truck or tractor/trailer as well as examination of shipping papers. Total truck time at the weigh scale, rest stop, or pullover point should not exceed three minutes, unless a safety inspection is also being conducted. A simple tally sheet, with rows or columns for the 25 or 30 most common four-digit hazardous materials codes (plus space to enter any additional codes observed) may be developed to ease analysis after the data have been recorded.

Exhibit 8 reviews the advantages and disadvantages of the data-recording procedures that can be used in surveys. On-site keying in with later confirmation from a copy of the shipping paper is, overall, the best means of recording. The data-processing resources for such quality assurance, however, may not be available. Similarly, both verbal and written communications to a data recorder on site provide an important accuracy check, but may necessitate the use of three-person teams. If data are to be keyed in later in an office rather than at the site, then both the survey transcription and a copy of the shipping paper should be available for a consistency check before final data entry.

If two-person teams are conducting the survey, two options are possible: (1) one person records the placard information and examines the truck exterior while the other transcribes the shipping paper data, or (2) one person collects all data and immediately provides them to the other person, who keys them into a computer data file. If data are to be entered into a computer at the survey site, some additional planning is necessary. Even with a laptop or portable personal computer (PC), AC power would likely be needed at the survey site. In addition, the recording location must be sheltered from the weather. A data-entry template should be prepared in advance and already coded into the software for easy and consistent keying of records.

EXHIBIT 8
ADVANTAGES AND DISADVANTAGES OF VARIOUS DATA RECORDING PROCEDURES

Pros	Cons
1. Hand Record for Remote Entry	
No need for electrical or telecommunications links	Requires considerable paper processing and tracking
One-person survey team feasible	Subsequent verification of shipping paper data not possible
Resource requirement relatively low	Long per-vehicle survey time
2. Hand Record for On-Site Entry	
Immediate verification and accuracy check feasible, especially if data screen has same format as check sheet	At minimum, two person team required Subsequent verification of shipping paper data not possible
3. Copy Shipping Paper	
One-person survey team feasible	Heavy-duty portable copier required
Fast (survey taker notes placard, copies bill, and sends trucker on his or her way)	Excessive paper handling and tracking required
Easily piggy-backed onto weigh station operations	No explicit check of placard/shipping paper consistency
4. Dictation Key-In	
Data recorder reports each value verbally to data entry specialist	
Instantaneous data recording	No paper record for subsequent verification
Fast processing of each vehicle	
5. Combining (2) and (3)	
Best verification and quality control option	Requires data entry and checking both during and after survey (i.e., more costly)
Data record in computer file is given same ID as shipping paper copy, assuring no mismatch or miscoding	
6. Combining (3) and (4)	
Faster than (5) and potentially as accurate	Same as (5)
7. Inclusion of Driver Interview	
May provide added insight on shipment frequency for a commodity of interest	Time consuming; increases survey cost, increases mean truck delay, and may require four-person teams

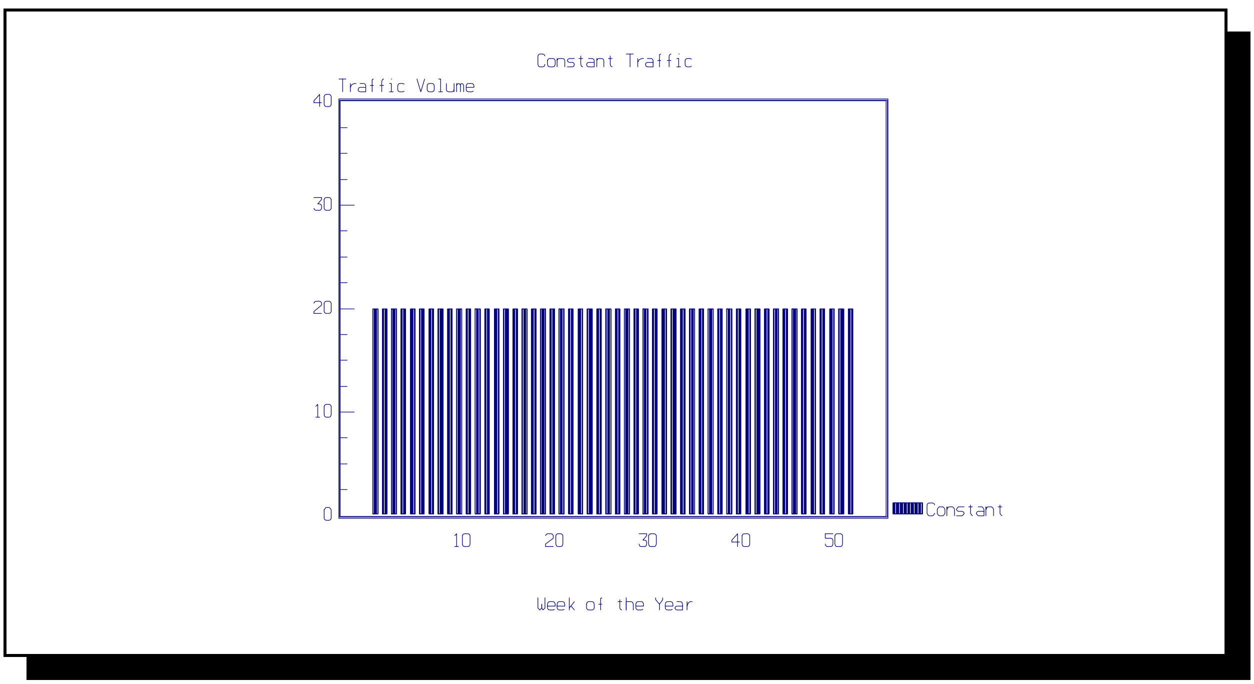
2.5 ANALYZE RESULTS

This section introduces the application of appropriate sampling techniques to the collection of highway hazardous materials flow data. It reviews some basic but important principles of sampling theory that are relevant to the planning of any survey of road traffic. Understanding the points covered is crucial to understanding why some surveys work while others do not, and why even a well-planned survey can sometimes yield erroneous, incomplete, or misleading results.

2.5.1 Statistical Considerations

The field of statistics uses models to predict reality. In this section, traffic flow is assumed to follow a Poisson distribution, which is a specific mathematical model used when discrete events (such as the movement of a truck carrying hazardous materials) occur randomly in time and space. To use the Poisson distribution, one must know the average number of occurrences per unit of time or space. This average number of occurrences is also referred to as the "expected value." For discussion purposes, assume weekly traffic flow is to be surveyed, although the discussion presented below holds for any time period (e.g., random event) chosen. Exhibit 9 represents traffic volume (y-axis units) that is constant for each week of the year (x-axis units). If traffic of a particular type were truly constant, then a survey could be conducted any week of the year and the results used to determine fortnightly, monthly, seasonal, or annual traffic flow. Actually, weekly traffic flow is random, although it may have the same expected average value each week of the year.

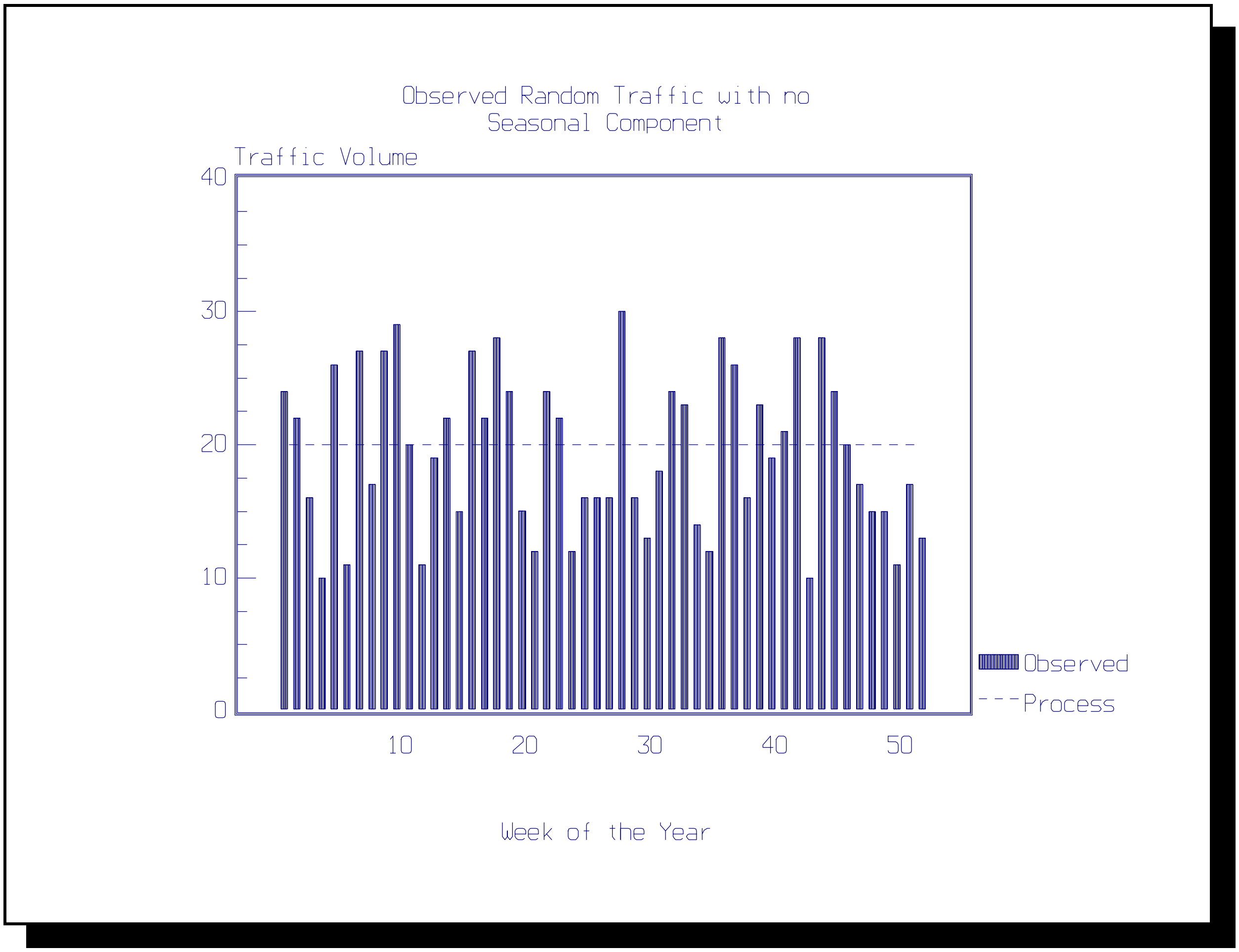
EXHIBIT 9
HYPOTHETICAL CONSTANT TRAFFIC FLOW



The bars of varying heights in Exhibit 10 depict random traffic levels per week. The dashed line at 20 units implies that the *expected* value of traffic each week is constant. The observed value varies around the expected value with probabilities established by the Poisson distribution.

EXHIBIT 10

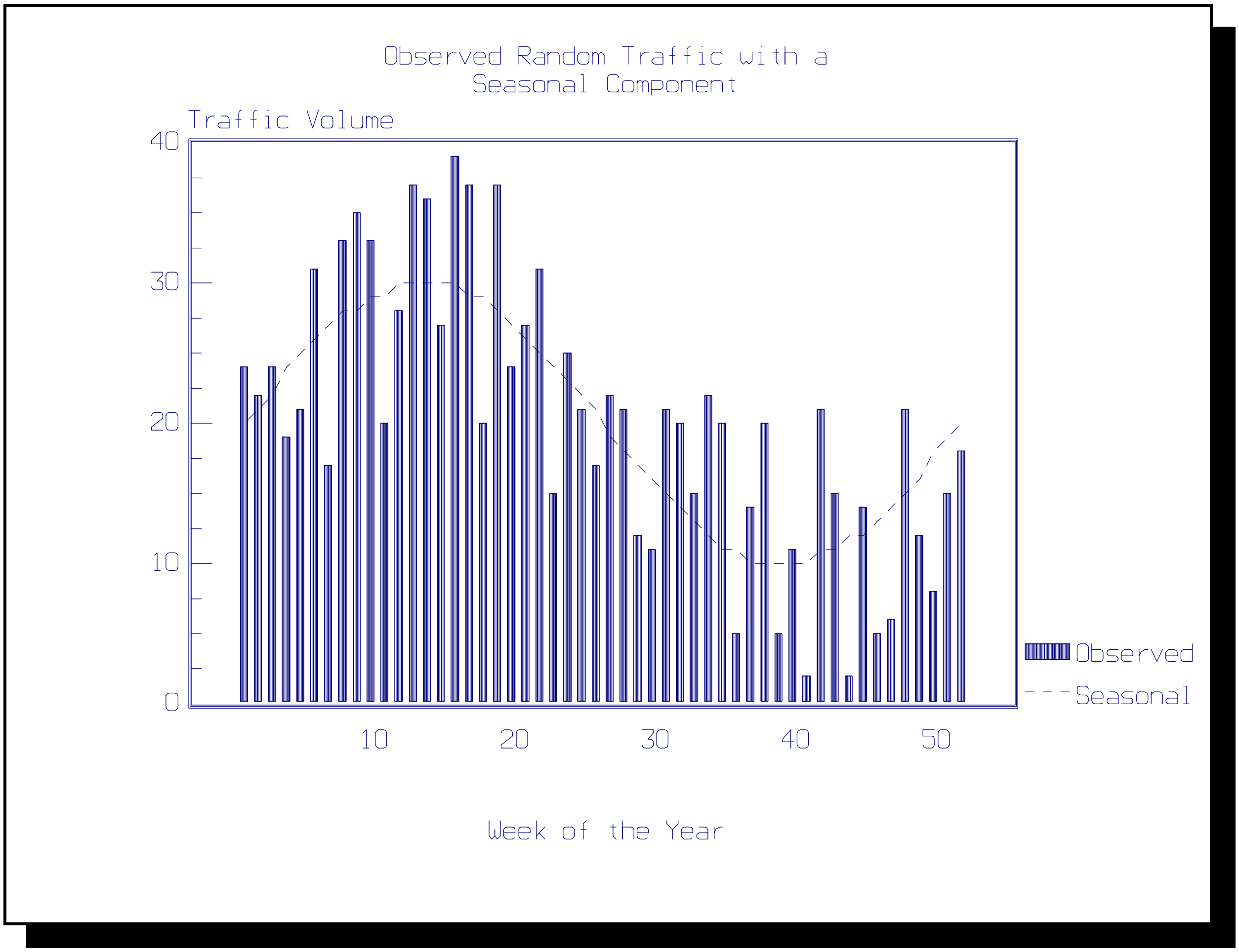
WEEKLY TRAFFIC FLOW PATTERN THAT IS RANDOM WITH NO SEASONAL COMPONENT



The researcher generally does not know the expected value, but only knows the observed value. If a survey were conducted during a random week, the researcher would have to be careful in drawing conclusions about periods other than the week in which the survey was conducted; it could lead to an incorrect estimate of the annual number of vehicles. For example, if the survey were conducted during a week when the observed value was 10 units and these results were used to estimate an annual flow of 520 units, annual flow would be underestimated by a factor of two (i.e., expected value of 20 times 52 weeks is 1,040 units). In real life, this may be acceptable. However, the point being made is that the results of a single survey may not be appropriate from a planning perspective and may need to be supplemented by other information about traffic flow, such as that obtained or inferred by LEPCs or through TRANSCAER.

Although the depiction in Exhibit 10 is more realistic than the previous one, it still is not precise because *expected* traffic volume is likely to vary throughout the year. The case shown in Exhibit 11 is more realistic, although still an oversimplification. The dashed curve represents this time-dependent variation in expected value, and each bar represents the random traffic level associated with the corresponding expected value. In Exhibit 11, the expected value changes every week of the year and the random variation in observed values makes the problem even more complex.

EXHIBIT 11
WEEKLY TRAFFIC FLOW PATTERN THAT IS RANDOM WITH A SEASONAL COMPONENT



Because of the nature of random traffic, what is seen at a particular observation point at any one location or any one time may not necessarily be a good indicator of overall average conditions. For example, if a traffic survey conducted over a week observes 100 shipments of a particular type, what can be reliably assumed about the actual number of shipments of this type at that specific location and time of year? First of all, unless other information is known, the average intensity of traffic flow (e.g., the expected value) can be assumed to be 100. However, the actual intensity may be higher *or* lower than 100, with 100 shipments having been observed simply by chance.

Exhibit 12 summarizes three confidence intervals (90%, 95%, and 99%) about a specific set of observed values. The middle column lists the observed values. Any particular confidence interval about a specific observed value is listed at the intersection of the appropriate row and pair of columns. The 90% confidence interval about the observed value of 100 is given under the third and fifth columns: namely, 85 to 118. Similarly, the 95% confidence interval is given under the second and sixth columns: namely, 82 to 122; and the 99% confidence interval is given under the first and seventh columns: namely, 77 to 129. When a researcher has an observed value, but does not know the expected value, Exhibit 12 can be used to determine the range of possible expected values that would be consistent with the one observed value. In other words, the 90% confidence interval (the range of plausible expected values 90% of the time) about the observed value of 100 is 85 to 118. In fact, there is a 5% chance that 100 or fewer shipments

EXHIBIT 12
CONFIDENCE INTERVALS VERSUS NUMBER OBSERVED

99% Confidence Interval							99% Confidence Interval						
	95% Confidence Interval							95% Confidence Interval					
		90% CI							90% CI				
LCL3	LCL2	LCL1[b]	N[a]	UCL1[c]	UCL2	UCL3	LCL3	LCL2	LCL1[b]	N[a]	UCL1[c]	UCL2	UCL3
0	0	0	0	3	4	7	176	183	187	210	235	240	251
0	0	0	1	4	6	9	185	193	197	220	246	251	262
0	1	1	2	6	7	10	194	202	206	230	256	262	273
1	1	1	3	8	9	12	203	202	206	240	256	262	273
1	2	2	4	9	10	13	212	221	225	250	277	283	294
2	2	2	5	10	12	15	222	230	235	260	288	294	305
2	3	3	6	12	13	16	231	240	244	270	298	304	316
3	3	4	7	13	14	18	240	249	254	280	309	315	327
3	4	5	8	14	16	19	249	258	263	290	319	325	337
4	5	5	9	15	17	21	259	268	273	300	330	336	348
5	5	6	10	17	18	22	268	277	282	310	340	346	359
5	6	7	11	18	20	23	277	287	292	320	351	357	370
6	7	7	12	19	21	25	286	296	301	330	361	368	380
6	8	8	13	20	22	26	296	306	311	340	372	378	391
7	8	9	14	22	24	28	305	315	321	350	382	389	402
8	9	10	15	23	25	29	314	325	330	360	393	399	412
8	10	11	16	24	26	30	324	334	340	370	403	410	423
9	11	11	17	25	27	31	333	344	349	380	413	420	434
10	11	12	18	26	28	33	342	353	359	390	424	431	444
11	12	13	19	28	30	34	352	363	368	400	434	441	455
11	13	14	20	29	31	35	361	372	378	410	445	452	466
19	21	22	30	40	43	48	370	382	388	420	455	462	476
27	29	31	40	52	54	60	380	391	397	430	465	473	487
35	38	40	50	63	66	72	389	401	407	440	476	483	497
43	47	49	60	74	77	84	399	410	416	450	486	494	508
52	55	58	70	85	88	95	408	420	426	460	497	504	519
60	64	67	80	96	100	107	417	429	436	470	507	514	529
69	73	76	90	107	111	118	427	439	445	480	517	525	540
77	82	85	100	118	122	129	436	448	455	490	528	535	550
86	91	94	110	129	133	141	446	458	465	500	538	546	561
95	100	103	120	139	143	152	493	506	513	550	590	598	614
104	109	113	130	150	154	163	540	554	561	600	642	650	667
113	119	122	140	161	165	174	588	602	609	650	693	702	719
122	128	131	150	172	176	185	635	650	658	700	745	754	772
131	137	141	160	182	187	196	683	698	706	750	796	806	824
140	146	150	170	193	198	207	730	746	755	800	848	857	876
149	156	159	180	203	208	218	778	795	803	850	899	909	928
158	165	169	190	214	219	229	826	843	852	900	951	961	981
167	174	178	200	225	230	240	874	891	901	950	1002	1012	1033
							922	940	949	1000	1053	1064	1085

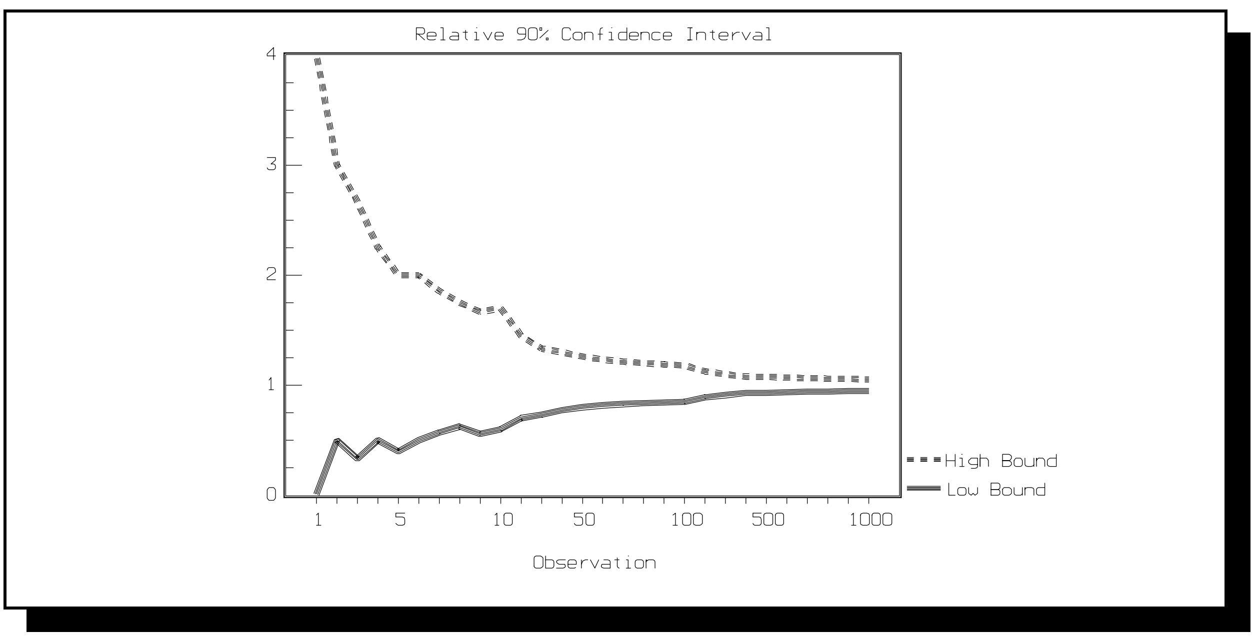
[a] N is the number observed.
[b] LCLn is the lower confidence limit (the probability is (1 - CI)/2 that the "true" intensity is **less** than the LCL for that CI).
[c] UCLn is the upper confidence limit (the probability is (1 - CI)/2 that the "true" intensity is **greater** than the UCL for that CI).

would be observed, even if the expected value was 118. Similarly, there is a 5% chance that 100 or more events would be observed, even if the expected value were 85.

It is possible to use Exhibit 12 to compare two observed values. For example, a community suspects that one of the four seasons has a high commodity flow, one has a low, and the other two have moderate levels of transport. This pattern is similar to the one illustrated in Exhibit 11, but unfortunately the dashed line in the exhibit, that indicates the expected transport flow, is not known before conducting a commodity flow survey. The goal of the commodity flow study is to determine whether there is a statistical difference in seasonal traffic. Before designing the study, an investigator knew that week 10 should have the highest weekly traffic and week 30 should have the lowest weekly traffic. After conducting the study and compiling the data, the investigator determined traffic flow was 30 units in week 10 and 16 units in week 30. The ranges that include a 90% confidence interval for these two values are 22 to 40 in week 10 and 11 to 24 in week 30. These ranges overlap. Both would be consistent with a "true" traffic intensity of 22, 23, or 24. This example illustrates the difficulty of using data developed from commodity flow studies to make meaningful, statistically accurate comparisons.

The size of a particular confidence interval increases as the observed value increases: for the observed values of 10 and 100, the 90% confidence interval sizes are 11 (the difference between 6 and 17) and 33 (the difference between 85 and 118), respectively. But, with respect to the observed value, the confidence interval *ratio* is decreasing (17 is 1.7 times 10 and 6 is 0.6 times 10; 118 is 1.18 times 100 and 85 is 0.85 times 100). Exhibit 13 illustrates this relationship for the 90% confidence interval. Similar results hold for the 95% and 99% confidence intervals. Thus, as sample size (N in Exhibit 12) increases, the proportional amount of error decreases.

EXHIBIT 13
CONFIDENCE INTERVAL VERSUS
NUMBER OF OBSERVATIONS



2.5.2 <u>Implications for Study Design</u>

The major lesson to be learned from this discussion is that there are dangers associated with trying to make inferences based on a small number of surveys or on any comprehensive survey of short duration. Traffic flows for longer or different periods of time may be grossly miscalculated and incorrect conclusions drawn. For example, statistical theory reveals, as shown in Exhibit 12, that 5% of the time when the observed value of a particular traffic type is 0, the expected value may be three. In this instance, it could be concluded that none of this type of traffic is ever present when in fact it may be present sometimes.

It is possible to make inferences based on small samples if the characteristics of the sample population are well known (i.e., if the expected value is known in advance of the survey). The known characteristics allow statisticians to adjust the observed results. For example, forecasts of economic indicators are made early in the year because the observations can be "seasonally adjusted" on the basis of historical data.

Thus, if reliable use is to be made of one or two surveys, information must be obtained about historical traffic patterns (e.g., peak periods, slack periods, and typical periods), and fixed sources of hazardous materials as well as the traffic flow from these sources (e.g., volumes, seasonality, and delivery routes) must be identified. LEPCs and public-use data bases (as described in section 2.2.2) can potentially provide this information.

Given the inherent difficulties and potentially high costs of traffic surveys, the following conclusions are generally applicable.

- Surveys should be done at the state level; that is, surveys should not be conducted unilaterally by local jurisdictions because it would not be valid to extrapolate data from a local survey to state-level conclusions, and components in state-level analyses should be based on consistent methods and data sources;
- Surveys should be carefully designed to ensure obtaining valid and useful results;
- Because when more "events" are observed the proportional size of the confidence range decreases, it may be more effective to sample for fewer time periods of longer duration; and
- Strange or unexpected results should be investigated further so that reasonable explanations can be found.

2.6 APPLY RESULTS TO PURPOSES

The results of the commodity flow study can be used to improve preparedness, prevention, and response capabilities by designating specific routes to be used for the transportation of hazardous materials and other focused planning efforts. For example, it may be useful to display the data on a map (or a series of maps) to obtain a picture of hazardous materials transport. Compare the data and conclusions that have been drawn from the study against the project goals identified at the beginning of the process in order to develop action items and a schedule for implementing the results. The study data and conclusions should be compared to the project goals identified at the beginning of the process. For example, if the study shows that a particularly large amount of a specific chemical is transported on a specific route, emergency responders along that route could benefit from training in the properties and effects of that substance. Equipment purchases could also be made with this information in mind.

> DALLAS CBD ! Statistics. After tallying the field and questionnaire data, several sources of information (MTB data, National Transportation Safety Board (NTSB) accident reports, and a DOE report on the risk of transporting gasoline by truck) were reviewed to better understand the causes and results of hazmat accidents. By reviewing these other sources of data and applying the information to local data, the Dallas CBD saved time and effort through its application of national trends to local realities. The Dallas CBD used statistics to determine how the national trends correlated to local data; this enabled the Dallas CBD to develop sound conclusions from its data without having to come up with its own complex methodology or hypotheses.

In some cases, those who develop and analyze the results of the commodity flow study might not be the most appropriate agent to take action on a particular recommendation. To implement the action items resulting from the study, it might be necessary to work with the state legislature, local governing bodies, or any one of the various state and federal agencies with responsibilities in transportation and environmental planning and emergency response.